ELECTRIC BIDET CONTROLS FOR OLDER ADULTS

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MASTERS PROJECT
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ACKNOWLEDGEMENT

First and foremost, I would like to acknowledge my **advisor Jon Sanford** and **committee members Leila Aflatoony and Dongha Lee**. They were a great source of research and design knowledge for me. Second, I would like to also acknowledge **Kohler Co. associates Dongha Lee, Jason Kim, Josh Hippert, and Barry Glasford**, who supported my project by providing bidet products for my purpose. Third, I would like to thank **Sam Harris**, GTID instructor and my friend, for helping me with the recruitment of elderly participants for my user study. Finally, I would like to thank my **interview and user study participants** whose insightful feedback contributed to the greater knowledge of bidets controls.

I am thankful that despite the COVID-19 situation, this project was able to come to a successful end.

BACKGROUND RESEARCH

Tushy.com

WHAT IS A BIDET SEAT?

A bidet seat is a device that attaches to an existing toilet . A bidet seat uses clean water to clean after toilet use and can save up to 75% of toilet paper. Bidet seats are currently widely popular in Asia . Smart advanced bidet seats are capable of more than just washing.

TASKS THAT BIDETS DO

TOILETING →	WASHING ⇢	DRYING	MAINTENANCE
Deodorize	Rear wash	Air dry	Self-sterilizing nozzle
Heated seat	Front (feminine) wash	Air dry temperature	Self-sterilizing bowl
	Water temperature	Air dry strength	Nightlight
	Spray strength		Power save (eco) mode
	Spray position		
	Oscillation		
	Pulsation		
	Spray width		

TERMINOLOGY

REAR WASH washes the buttocks after elimitation using a targetted water spray.

FRONT (FEMININE) WASH washes feminine parts using a wide water spray.

AIR DRY is a touch-less drying function using a warm stream of air.

DEODORIZE eliminates unpleasant odors inside the bowl using a scent-neutralizing charcoal filter.

HEATED SEAT keeps the seat at a pleasurable temperature.

SELF-CLEANING NOZZLE keeps the nozzle clean using water or UV-light sterilization process when it's retracted.

NIGHTLIGHT illuminates the toilet bowl at night to help user find their way at night.

OSCILLATION & PULSATION of the water offer a more effective cleaning technique. Oscillation makes the nozzle move back and forth whereas pulsation repeptitively and quickly turns water on and off.

BIDET TYPES

Bidet attachments

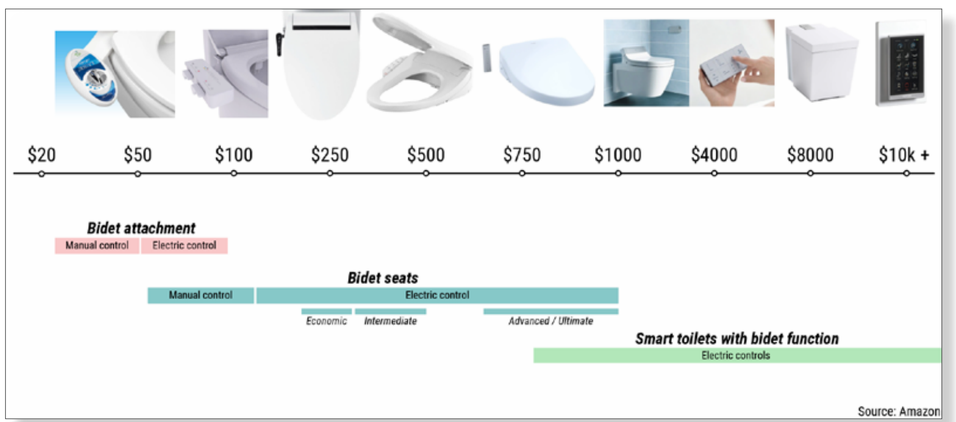
It is a non-electronic toilet-top attachment with basic functions which are operated by a side panel with a knobs. As of 2020, their price ranges between $25 and $99.

Bidet seats

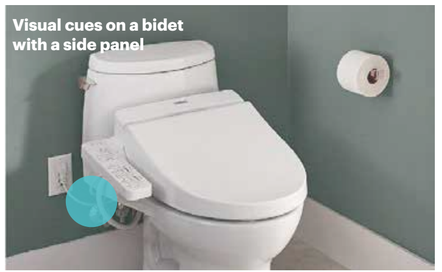
Bidet seats come with a seat and can offer intermediate and advanced functions. More affordable seats have manual controls, but most bidet have electric controls. More economic options have a side control panel, while more advanced options come with a remote control. The price range is between $55 and $1000.

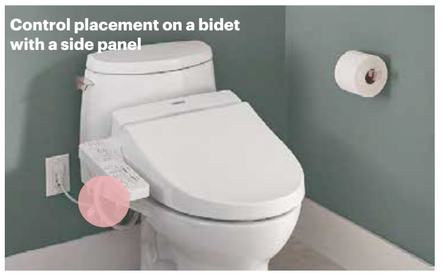
Smart toilets

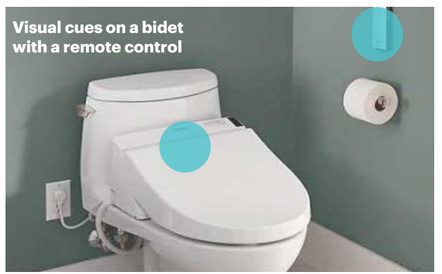
Smart toilets are comparatively less common in the US market. They are the most expensive bidet products but are not much more advanced than the most advanced bidet seats. They are operated by a remote control.

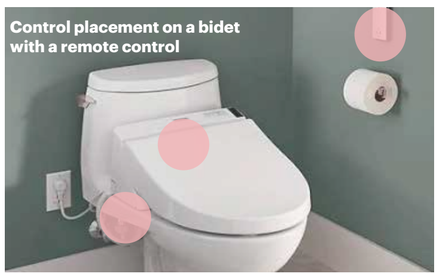


VISUAL CUES & CONTROL PLACEMENT









VOICE-CONTROLLED

REMOTE CONTROLS

Unlike bidet attachments, bidet seats come with a seat and can offer intermediate and advanced functions. More affordable seats have manual controls, but most bidet have electric controls. More economic options have a side control panel, while more advanced options come with a remote control. The price range is between $55 and $1000.

PHONE APP

1 - DURAVIT
$1000, premium seat
Cards with multiple languages

2 - Kohler
$8000, premium toilet
Controlled with Alexa

3 - DURAVIT
$1000, premium seat

4 - Alpha Bidet
$264, economic seat

5 - Kohler
$3795, premium toilet

6 - BioBidet
$629, premium seat

7 - OVE
$288, intermediate seat

8 - Novita
$326, intermediate seat

WALL-MOUNTED

SIDE PANEL

ONLINE RESEARCH

There is no rule to how the remote controls functions should be organized. Most remotes display all the functions in a single layer of information.

Spray activation

Stop

Dry

Pressure

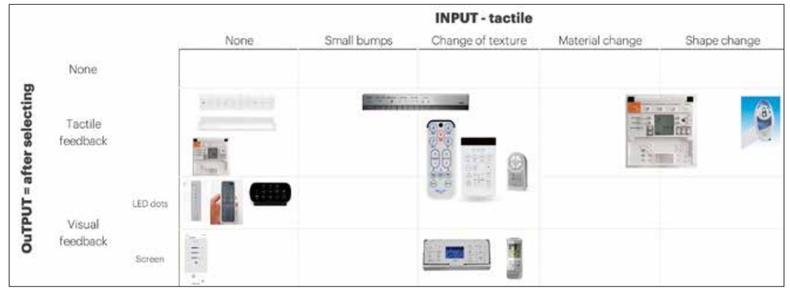
Nozzle position

Temp adjustment

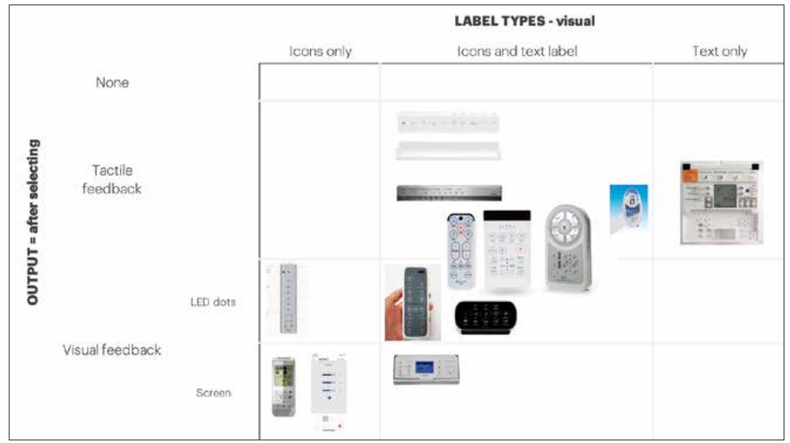
Other

CONTROL ANALYSIS

ORGANIZING REMOTES BASED ON TYPES OF TACTILE INPUTS



ORGANIZING REMOTES BASED ON TYPES OF VISUAL INPUTS



HANDS-ON RESEARCH

Inax Side Panel Control
Hard to read due to the glossy finish and small graphics; poor posture; controls in the back are hard to reach

Veken Knob Control
On/Off and Position spray in one control; Few but small graphics

Kohler Remote Control
Not ergonomic in hand; Preset controls are limited to 2 users and hard to see

Novita Wall-Mounted Control
Poor hand posture when picking it up; Not designed to be held in hands; Large, easy-to-understand graphics

Inax Wall-Mounted Control
Not designed to be picked up or held in hands; Too many controls and screens; Confusing visual hierarchy

INTERVIEWS & BIDET USERS

6 interview participants shared their every-day experience with using their electric bidet. Quotes from the interviews were distilled into insights.

DESIRE FOR SIMPLICITY

"Bidet should serve a very simple purpose and the way you operate it should be **simple and straightforward.**"

Bidet users would like the bidet control to be simple and easy to understand.

POSITIONING

"I either scood over when the spray is a little off or I change position settings when the spray is way off."

"I don't have to change position frequently because my spray **oscillates** by default."

"My bidet had 3 position settings and no oscillating function. I'd **change the position every 10 seconds or so to make sure that I felt clean.**"

Positioning has to be precise. However, people sit on the toilet differently every time. Users are willing to move their body towards the spray if the difference is small. When the spray is constant, positioning may be used incorrectly to achieve a cleaner effect. Oscillation of the spray can reduce the need for precise positioning while delivering a more effective cleansing experience.

FREQUENCY OF USE

Spray position: range from never to always depending on whether the spray oscillates
Water pressure: almost never changes unless he/she has a medical condition
Water temperature: changes occassionally based on subjective factors like mood, weather, or season

CONTROLS CAN BE MISPLACED

"Sometimes I misplace my remote control... I usually put it not top of the toilet tank instead of the case on the wall because it is flimsy. And then **I forget that it's there.**"

Docking mechanism should be easy to do.

DESIRE FOR PRESETS

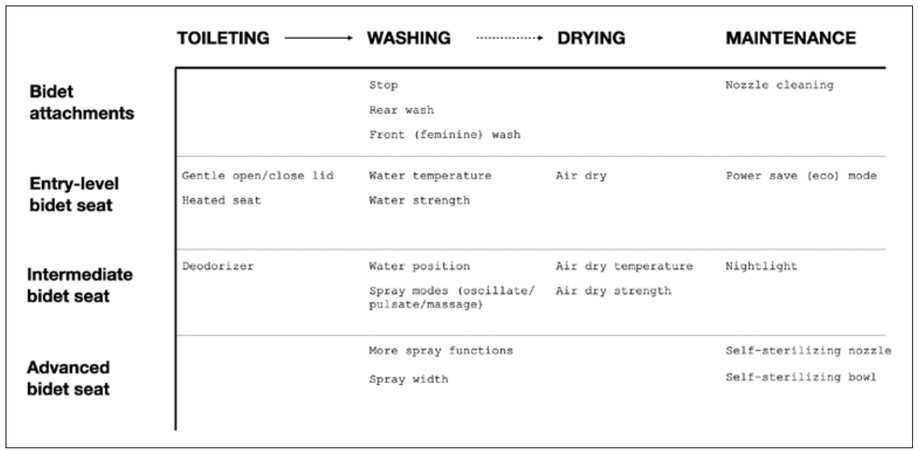
"I wished that I had presets **so that different people could set it up differently.**"

"I have to adjust the spray settings every time because my husband's presets are the default."

Bidet users expressed a desire for presets to reduce the likelihood of changing settings in a multiple-user scenario.

ORGANIZING INFORMATION

*HIERARCHY OF FUNCTIONS BASED ON **THE CURRENT MARKET***



	TOILETING →	WASHING ⇢	DRYING	MAINTENANCE
Bidet attachments		Stop Rear wash Front (feminine) wash		Nozzle cleaning
Entry-level bidet seat	Gentle open/close lid Heated seat	Water temperature Water strength	Air dry	Power save (eco) mode
Intermediate bidet seat	Deodorizer	Water position Spray modes (oscillate/ pulsate/massage)	Air dry temperature Air dry strength	Nightlight
Advanced bidet seat		More spray functions Spray width		Self-sterilizing nozzle Self-sterilizing bowl

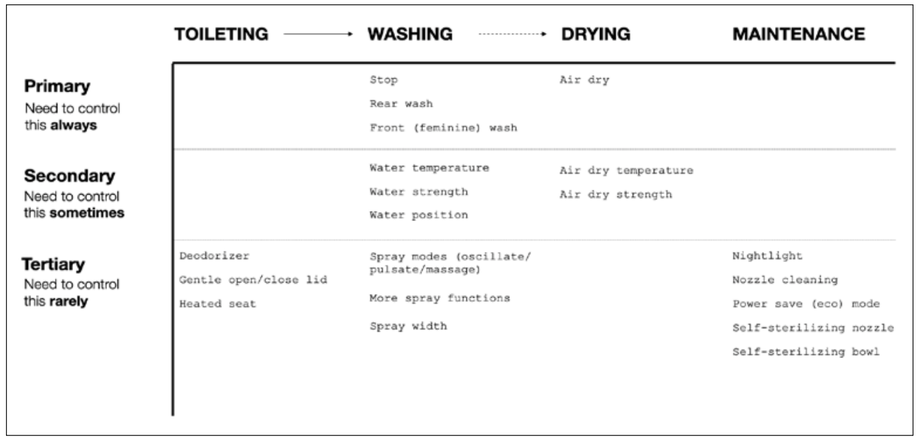
PRIMARY FUNCTIONS

Although **front (feminine) wash and air dry** are not always used, they belong **on the same level of importance as rear wash.** All three always need to be controlled when the bidet is operating.

SECONDARY FUNCTIONS

Secondary functions are **"parameters" to the primary functions. Water temperature, strength, and position** only need to be controlled sometimes. When the default spray is oscillating, the need to change the position and the need for precision decreases (from interviews).

*HIERARCHY OF FUNCTIONS BASED ON **MY RESEARCH QUESTION***



	TOILETING →	WASHING ⇢	DRYING	MAINTENANCE
Primary Need to control this **always**		Stop Rear wash Front (feminine) wash	Air dry	
Secondary Need to control this **sometimes**		Water temperature Water strength Water position	Air dry temperature Air dry strength	
Tertiary Need to control this **rarely**	Deodorizer Gentle open/close lid Heated seat	Spray modes (oscillate/ pulsate/massage) More spray functions Spray width		Nightlight Nozzle cleaning Power save (eco) mode Self-sterilizing nozzle Self-sterilizing bowl

TERTIARY FUNCTIONS

Tertiary functions are rarely controlled. These functions can be: **1. a part of the default settings, 2. automated, or 3. found under settings.** They are not needed when the bidet is running. **Oscillation and pulsation** raise the effectiveness of the spray and therefore are not necessary to control if they are a part of the default setting. **Deodorizer, gentle open/close lid, heated seat, nightlight, nozzle cleaning, and eco mode** can ideally be automated and found under settings when adjustment are needed (which happens rarely).

WHAT ARE THE PROBLEMS?

Bidet controls represent the capabilities of bidet seats. However, current bidet controls display too much information, are not easy to use, hold, and read.

PURPOSE

The purpose of this project is find a **usable and useful solution** to a bidet control design.

RESEARCH QUESTIONS

How to organize information to maximize usability?
What type(s) of interactions are comfortable to do?
What physical form to facilitate ease of use?

TARGET GROUP

A large target group with **variable differences and needs** who can benefit from this product as they age and their abilities decline.
Varying degrees and combinations of **vision, hearing, dexterity, mobility, and cognition limitations.** Varying degrees of **technology proficiency**

DESIGN CRITERIA

Design guidelines for the elderly and for accessibility, patents on emerging technologies, and interview insights, were reviewed and distilled into a list of design criteria to guide the process of designing a successful remote control for the elderly.

Information Hierarchy

1. The most **basic functions** need to be easiest to access at all times.
2. Information needs to be **grouped** in a way that is easy to understand.
3. **Deep menu-driven hierarchies** should be avoided.
4. **Include presets** to reduce the likelihood of changing settings with multiple users.
5. **Include heart rate sensor** for a hands-free user identification.

User Interface & Controls

1. **UI touch targets** should have at least 14mm in height and width. Larger is even better. Touch target spacing should be at least 8dp.
2. **The spacing** between physical buttons shouldn't be smaller than 1.5mm to avoid accidental activation.
3. **Icons** need to communicate functions clearly and should not create confusion.
4. **Labels** should be written in sentence case in sans serif and UI font size should be at least 12pt.
5. **Contrast** - if the text is smaller than 18pt, or if the text is bold and smaller than 14pt, the color contrast ratio should be at least 4.5:1. For all other text, the color contrast should be at least 3.0:1.
6. Include **multi-modal input and output** to accommodate for people with varying degrees of vision, hearing, and dexterity limitations.
7. The only gestures for controlling the UI should be **limited to tapping and dragging.**
8. To avoid disrupting the circadian rhythm, include **"dark mode" or keep the screen turned off.**

Physical Form

1. Should be **operable by one hand** if held.
2. Should be **operable by one finger** if attached to a flat surface.
3. Needs to be **easy and comfortable to use**.
4. The right **orientation** should be apparent.
5. **Material** used should be lightweight and the finish should not be slippery. Needs to be waterproof and easy to clean.
6. Shouldn't be easily **misplaced**.
7. Easy integration into the **existing bathroom**.

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The first 3 design criteria for information hierarchy come from existing UI/UX design guidelines for the elderly or for accessibility. Applications of such guidelines were found in some peer-reviewed journals.

IDEO UX/UI for the Elderly

Android UI Design Guidelines on Accessibility

Smart Remote Control Design for Seniors

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5. **Include heart rate sensor** for a hands-free user identification.

Presets are a desired feature for a multi-user scenario. Current presets are limited to only 2 users and can be improved upon.

"I have to adjust spray settings every time because the default settings are my husband's."

"I wish that mine had presets so that different people in my family could set it up differently."

Interviews with Bidet Users

Study of the Remote Control of a Kohler C-XXX

INFORMATION HIERARCHY

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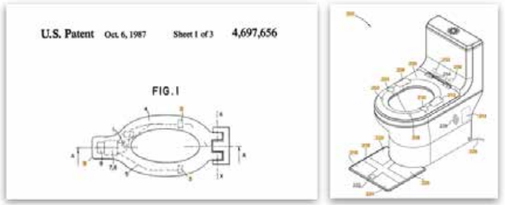
5. **Include heart rate sensor** for a hands-free user identification.

Hands-free user identification is desirable as it can simplify the way users access their presets. Users can be identified by built-in sensors on the seat. **Heart rate sensors can accurately identify users based on their heart rate pattern.** It is also the most economic and reliable type of sensor for our purposes.



Patent: Weight distribution sensor in a toilet seat

Heart rate pattern to confirm user identity

PHYSICAL FORM

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National Disability Authority: Guidelines for Digital TV Equipment and Services - Remote controls

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"Sometimes I misplace my remote control. Usually puts it not top of toilet tank instead of the case on the wall because it is difficult to put it back."

Interviews with Bidet Users

Remote controls cannot be misplaced in the bathroom. It is important to design a docking system that minimizes the risk of misplacement.

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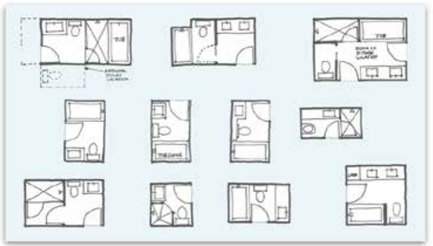
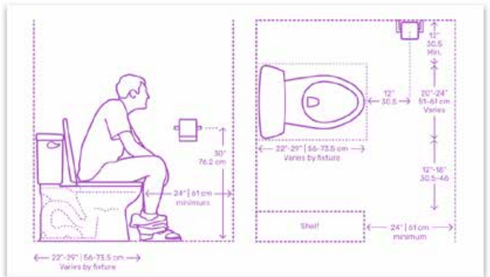


Common Bathroom Floor Plans: Rules of Thumb for Layout



Dimensions.com: Bathroom Clearances

Common bathroom layouts and clearances were taken in consideration. All information is relevant for US bathrooms only. It was found that the most standard residential bathroom layouts have at least one vertical surface within users' reach from the toilet.

PHYSICAL FORM

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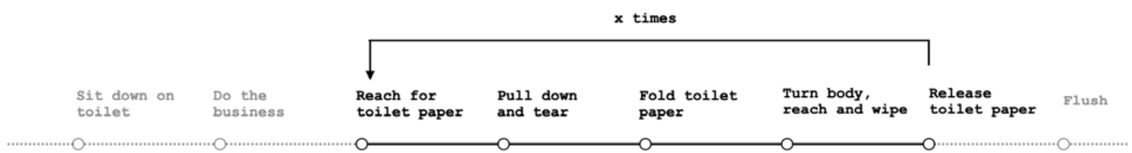
7. Easy integration into the **existing bathroom**.

It is also important to ensure that the remote can be easily intergrated into the existing users' routine. Controlling the bidet should be as simple and straightforward as possible.



JOURNEY MAP OF TOILET PAPER USE

USER INTERFACE & CONTROLS

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6. Include **multi-modal input and output** to accommodate for people with varying degrees of vision, hearing, and dexterity limitations.
7. The only gestures for controlling the UI should be **limited to tapping and dragging.**
8. To avoid disrupting the circadian rhythm, include **"dark mode" or keep the screen turned off.**

IDEO UX/UI for the Elderly

Android UI Design Guidelines on Accessibility

WebAIM Contrast Checker

All of the criteria for designing UI and controls were found in existing UI design guidelines for the elderly and for accessibility as well.

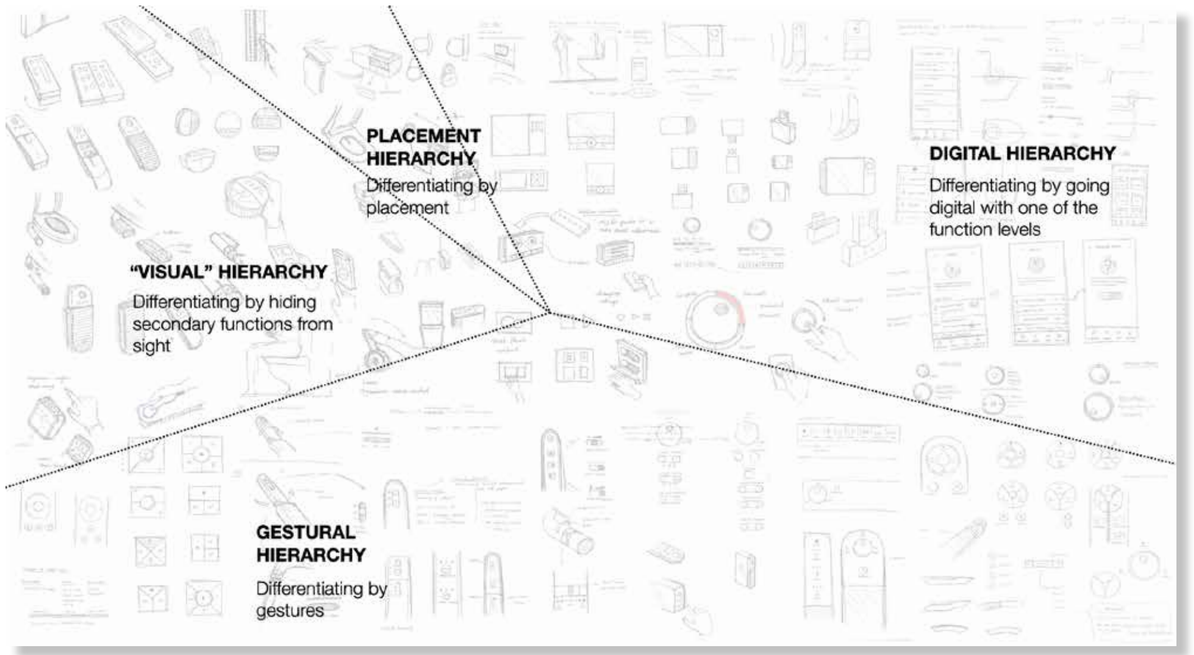
DESIGN PRINCIPLES

The list of design criteria is fairly long. For practical reasons I created **3 design principles that would guide me towards the right design solution at the earlier stages of ideation**. The design principles encompass an overall message of the design criteria in each category.

INFORMATION HIERARCHY	**Minimize interaction** on all levels of the information hierarchy.
PHYSICAL FORM	**Seamless intergration** into the existing bathroom and routine.
USER INTERFACE & CONTROLS	Easy to understand at a glance. Easy to control. Include **multi-modal input and output.**

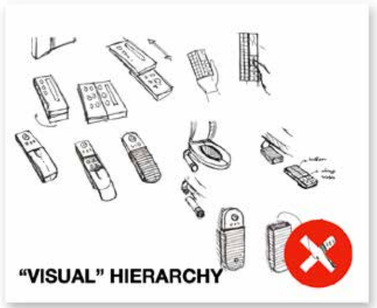
IDEATION ROUND 1

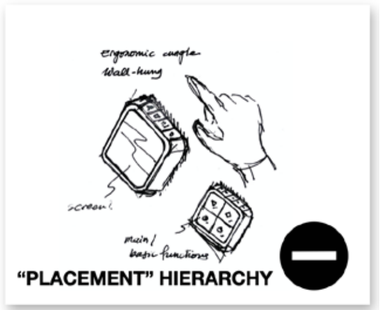
The first round of ideation was focused on exploring ways to **differentiate primary and secondary functions.** Ideas were grouped into four categories.

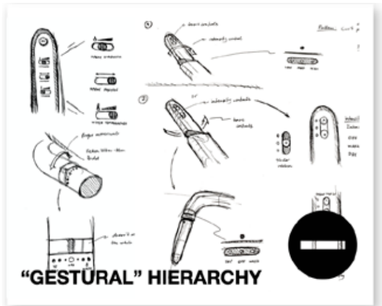


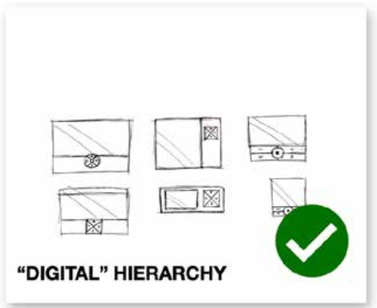
WHICH ONE CAN MINIMIZE INTERACTIONS?

Digital hierarchy is the only type of hierarchy that can show or hide information from the user and at the same time reduce the amount of interaction. A device that contains visual hierarchy will inevitably add more interaction, whether in a form of sliding or flipping, whereas devices with placement or gestural hierarchy will neither add nor reduce the amount of interaction.





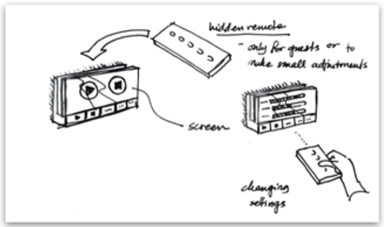




Minimize interaction on all levels of the information hierarchy.

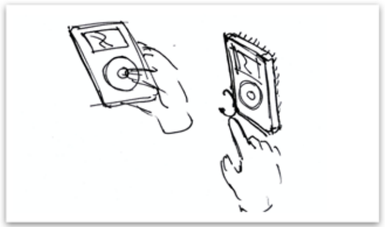
CONCEPTS
DIGITAL REMOTES

3 ways of organizing functions to create 3 concepts for a digital remote control.



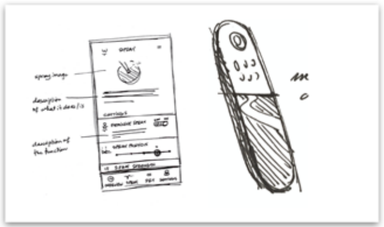
MONITOR WITH A SIMPLE REMOTE

The monitor is attached to the wall in front of users while they are seated. The simple remote control which contains controls for primary functions is also used to operate the monitor that displays secondary functions.



TOUCH SCREEN DEVICE WITH PHYSICAL CONTROLS

The touch screen is for controlling secondary functions. The set of physical controls is for controlling primary functions.



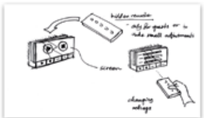
SIMPLE REMOTE CONNECTED TO AN APP

The simple remote only contains controls for primary functions. Secondary functions are accessed only via a phone or tablet app.

CONCEPT EVALUATION

Concept 2 was the only one that included multi-modal input for both primary and secondary function.

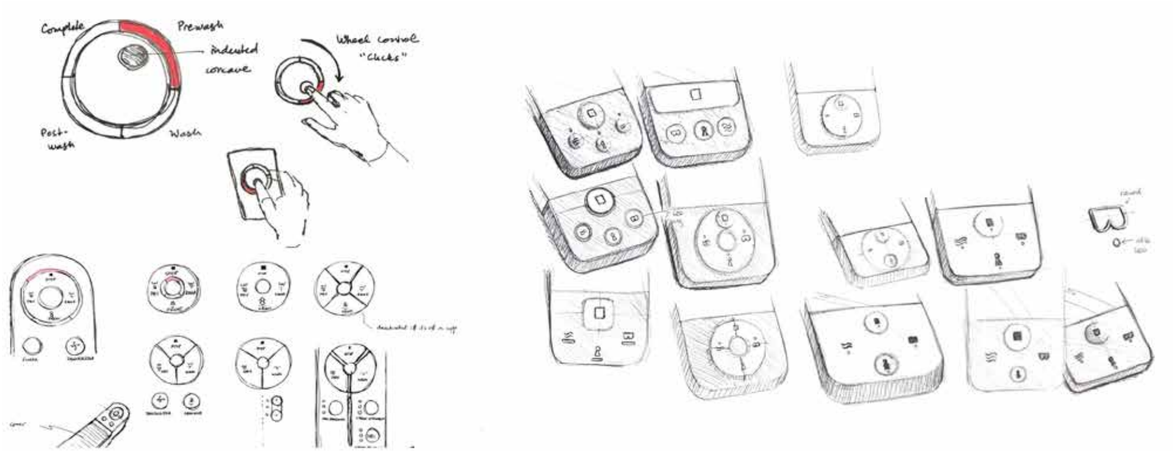
Easy to understand at a glance. Easy to control. **Include multi-modal input and**



Types of input for primary functions	1 MONITOR WITH SIMPLE REMOTE	2 TOUCH SCREEN DEVICE WITH PHYSICAL CONTROLS	3 SIMPLE REMOTE CONNECTED TO AN APP
Tactile	✓	✓	✓
Visual	✓	✓	✓
Voice	✓	✓	✓
Types of input for secondary functions			
Tactile		✓	
Visual	✓	✓	
Voice	✓	✓	✓

IDEATION ROUND 2

How to create hierarchy within the primary functions? How to distinguish rear wash, front wash, air dry, and stop in a way that is easy to understand? What is the relationship among these functions?



There is a certain order to the primary functions. Air dry follows wash, stop follows air dry or wash**. Organizing functions in a circular layout can convey the cyclical nature of the process.**

However, people can sometimes go back and forth between functions. They may also opt to skip functions based on their preference. **I tried to come up with a layout of buttons that conveyed the idea of a "cycle or process" but still allowed users to choose their preferred functions in the end.**

TESTING SURFACE AREA

Does the control need to be hand-held?
Yes, because some bathroom layouts may not have a vertical surface close to the toilet.

How large do the buttons need to be?
Ideally at least as large as current buttons.

How big is this device?
I used a smartphone as initial size reference because it is a touch-screen device that is designed for one-hand use.

Seamless integration into the existing bathroom and routine.

TESTING SIZE & PLACEMENT

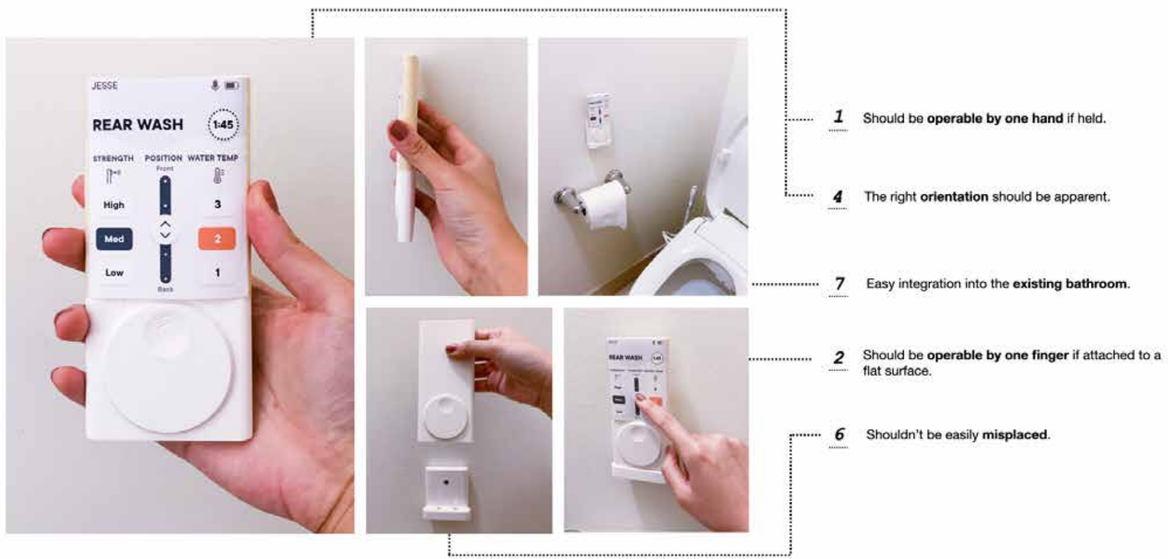
4 detailed prototypes with different sizes were created and testing to determine the size that “feels right” in my small female hands. **Touch target size and thumb reach** were considered.

A magnetic dock was also tested with the device at the key places in the bathroom. Testing considered the **ease of removing and reattaching the device** to the dock.

UI EVOLUTION

This was my first UI/UX project and the user interface underwent many **iterations both in terms of graphic design and UI flow**. I paid special attention to the design of the controls on the touch screen. How many levels of precision do users need for each function? How much space do we have for tapping or dragging with finger? How to graphically differentiate one function from another?

PROTOTYPE
PHYSICAL FORM



1 Should be **operable by one hand** if held.

4 The right **orientation** should be apparent.

7 Easy integration into the **existing bathroom**.

2 Should be **operable by one finger** if attached to a flat surface.

6 Shouldn't be easily **misplaced**.

PROTOTYPE
UI & CONTROLS

8.44:1 — 5 **Contrast** - if the text is smaller than 18pt, or if the text is bold and smaller than 14pt, the color contrast ratio should be at least 4.5:1. For all other text, the color contrast should be at least 3.0:1.

16mm x 16mm — 1 **UI touch targets** should have at least 14mm in height and width. Larger is even better. Touch target spacing should be at least 8dp.

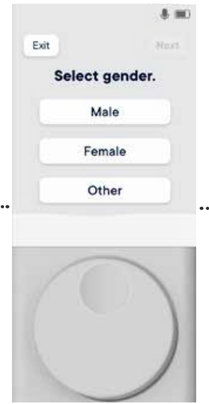
24dp

14pt — 4 **Labels** should be written in sentence case in sans serif and UI font size should be at least 12pt.

A lot more — 2 **The spacing** between physical buttons shouldn't be smaller than 1.5mm to avoid accidental activation.

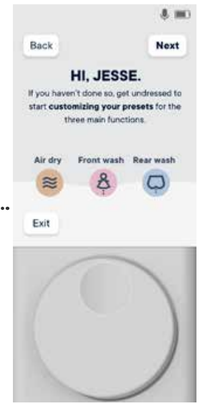
PROTOTYPE
CREATING USER PROFILE

HOME PAGE
Click on create user profile

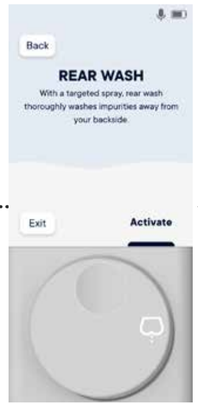


SELECT GENDER
Males will never have the option to adjust or even view front (feminine) wash.

CREATE USERNAME

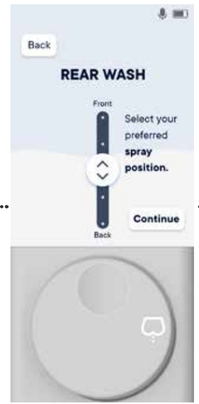


HI, [NAME]
Introduction to the three primary functions.

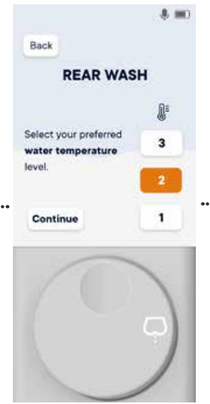


REAR WASH INTRO
Explanation of what rear wash does. Activating rear wash.

REAR WASH SPRAY STRENGTH SETTING
Adjusting spray strength based on preference.

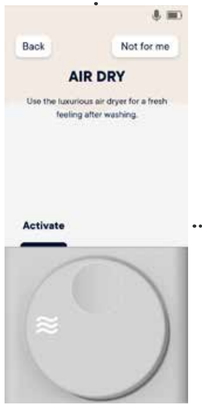


REAR WASH SPRAY POSITION SETTING
Adjusting spray position based on preference.

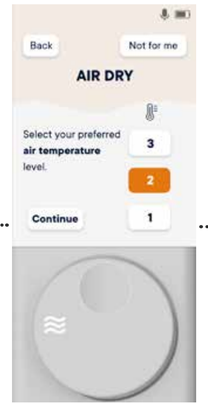


REAR WASH WATER TEMPERATURE SETTING
Adjusting water temperature based on preference.

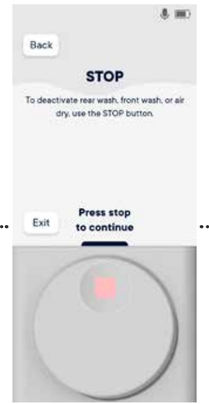
`FRONT WASH (spray strength, position, temperature)`



AIR DRY INTRO
Explanation of what air dry does. Activating air dry.

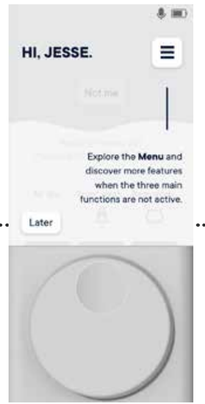


AIR DRY TEMPERATURE SETTING
Adjusting air dry temperature based on preference.

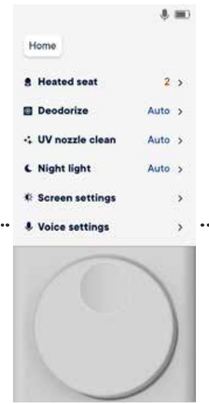


STOP INTRO
Explanation of how to stop any function.

SAVED!
Settings are saved. Preview included.



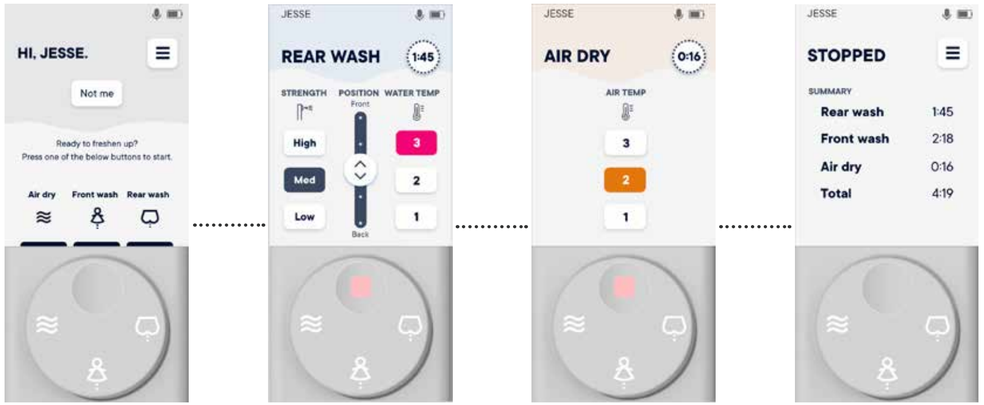
HI, [NAME] EXPLORE MENU
Suggestion to explore more features. Optional step.



MENU
List of additional features (tertiary functions). Most are on Auto.

HEATED SEAT
Adjusting heated seat.

PROTOTYPE
CONTROLLING BIDET



HI [NAME] HOME PAGE
Option to start wash or dry.

REAR WASH
Rear wash is turned on. Option to adjust rear wash settings. Front wash page looks the same.

AIR DRY
Air dry is turned on. Option to adjust air dry settings.

STOPPED
This page pops up when wash or air dry are stopped. Summary of how long each function was used.

VIRTUAL USER STUDY

METHODOLOGY
USER STUDY TIMELINE
EVALUATION TECHNIQUES

METHODOLOGY

METHOD

The user study had to be virtual due to Covid-19 restrictions. The study was held on Bluejeans video conference platform.

RECRUITMENT

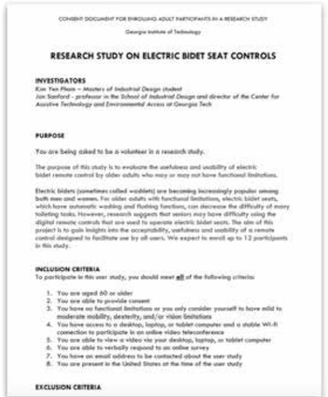
Participants were recruited via connections. Prior to the study they would receive an email with instructions, consent form, and recruitment flyer.

LIMITATIONS

Participants cannot interact with physical models of the remote and therefore cannot give accurate feedback on the physical form. They also cannot experience the actual bidet during this study.

SUBJECTS

Participants must be **at least 60 years old** to qualify for the user study. Participants with **no or mild to moderate level of any limitation** were qualified for the user study. Participants with severe vision, hearing, or cognition limitation were excluded as they cannot complete the study in this format. Due to the limitations of the virtual format, I decided to include **design professionals** who I thought might give more detailed feedback compared to regular participants.


CONSENT DOCUMENT FOR ENROLLING ADULT PARTICIPANTS IN A RESEARCH STUDY

Georgia Institute of Technology

RESEARCH STUDY ON ELECTRIC BIDET SEAT CONTROLS

INVESTIGATORS

PURPOSE

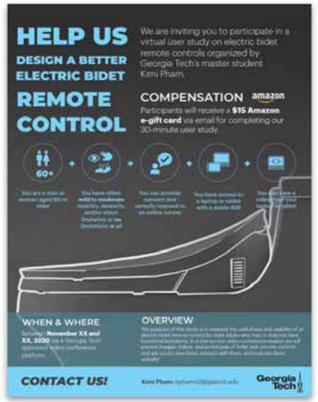
You are being asked to be a volunteer in a research study.

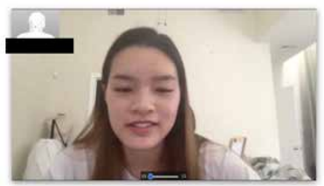
INCLUSION CRITERIA

To participate in this user study, you should meet all of the following criteria:

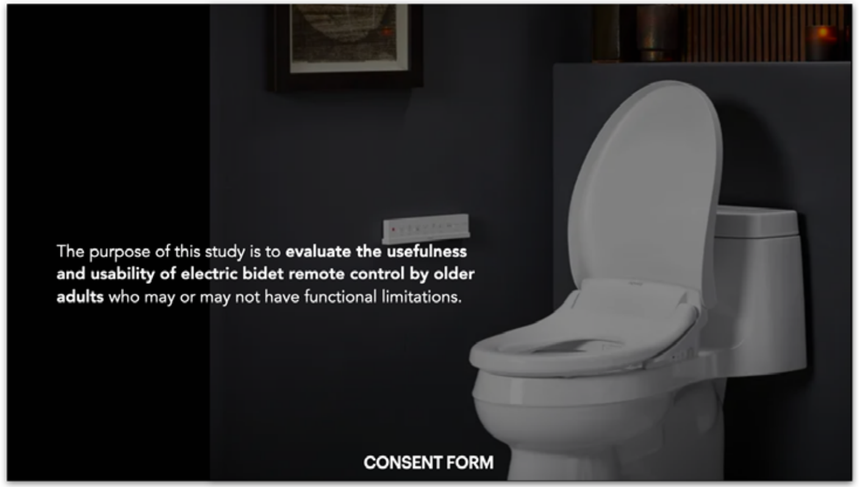
1. You are aged 60 or older
2. You are able to provide consent
3. You have no functional limitations or you only consider yourself to have mild to moderate mobility, dexterity, and/or vision limitations
4. You have access to a desktop, laptop, or tablet computer and a stable Wi-fi connection to participate in an online video teleconference
5. You are able to view a video via your desktop, laptop, or tablet computer
6. You are able to verbally respond to an online survey
7. You have an email address to be contacted about the user study
8. You are present in the United States at the time of the user study

EXCLUSION CRITERIA



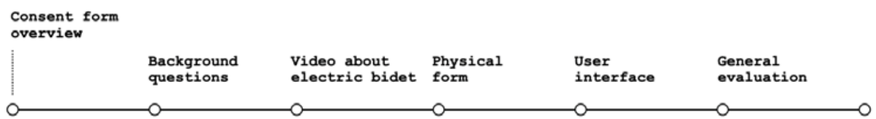


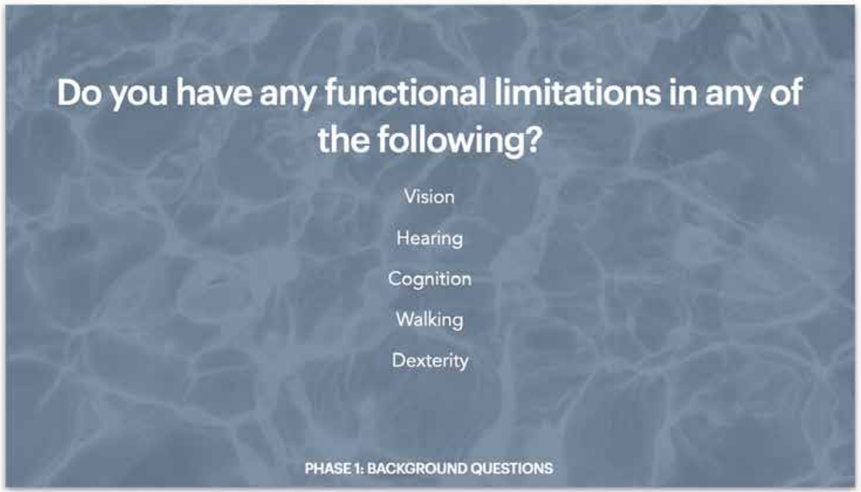
TIMELINE



CONSENT FORM OVERVIEW

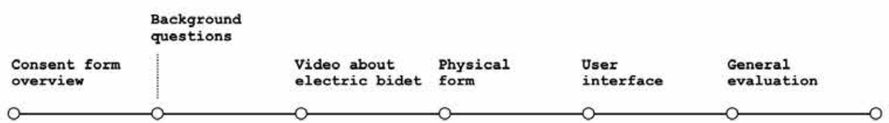
Inclusion criteria
Purpose
Procedure
Outline
Participants' rights
Compensation
Verbal consent

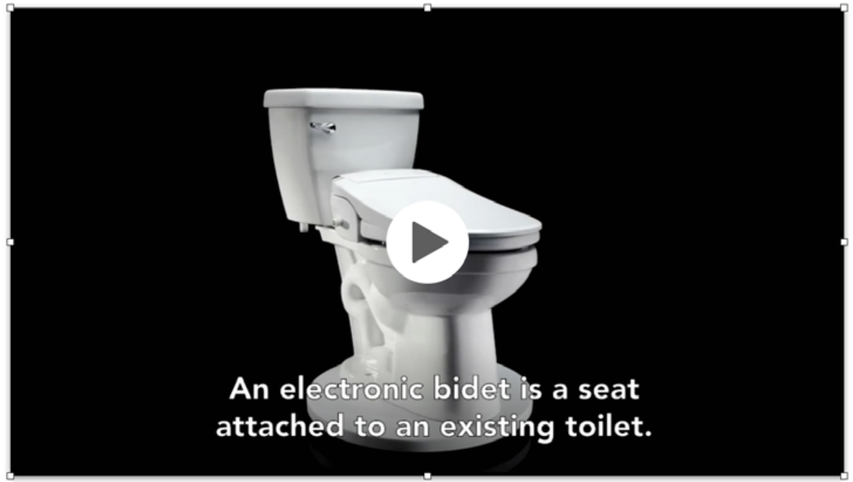




BACKGROUND QUESTIONS

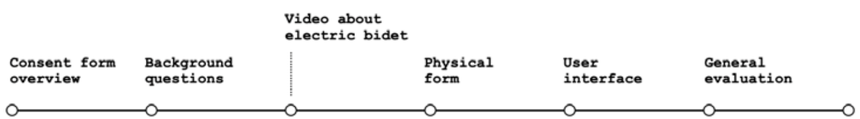
Age
Gender
Functional limitation types
Severity of limitation(s)
Familiarity with bidet





VIDEO ABOUT ELECTRIC BIDET

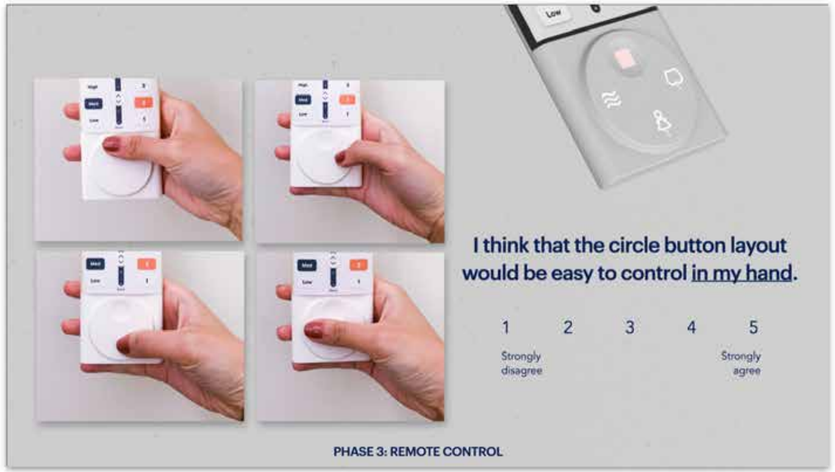
What a bidet seat does
Comparison to toilet paper
Rear and front spray
Temperature, strength, position
Air drying
UV nozzle sterilization
Deodorizer
Heated seat
Nightlight
Automatic open/close lid



PHYSICAL FORM

Videos and photos of the remote
Size
Placement
Interactions
Q&A

Consent form overview — Background questions — Video about electric bidet — **Physical form** — User interface — General evaluation



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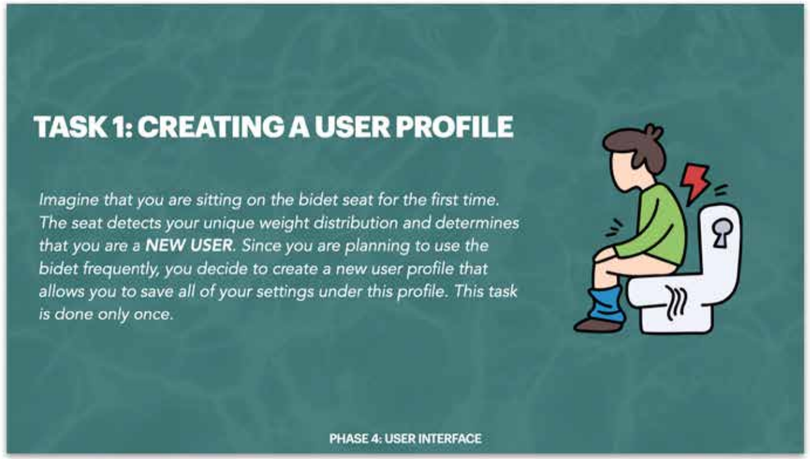
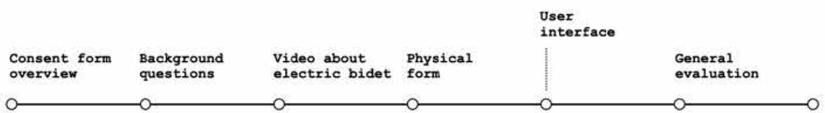


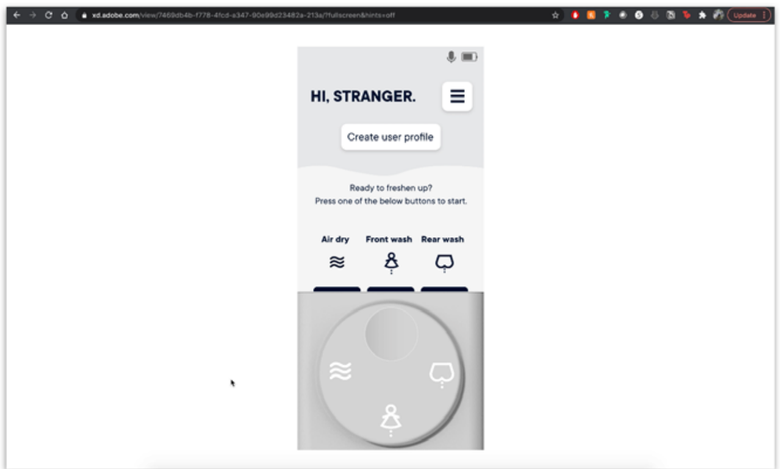
USER INTERFACE

Instructions:
Shared UI prototype on screen
Participants are asked to speak aloud and give verbal commands

Tasks:
Create user profile
Control the bidet

Q&A:
Flow
UI design





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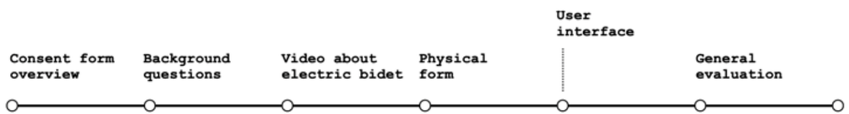

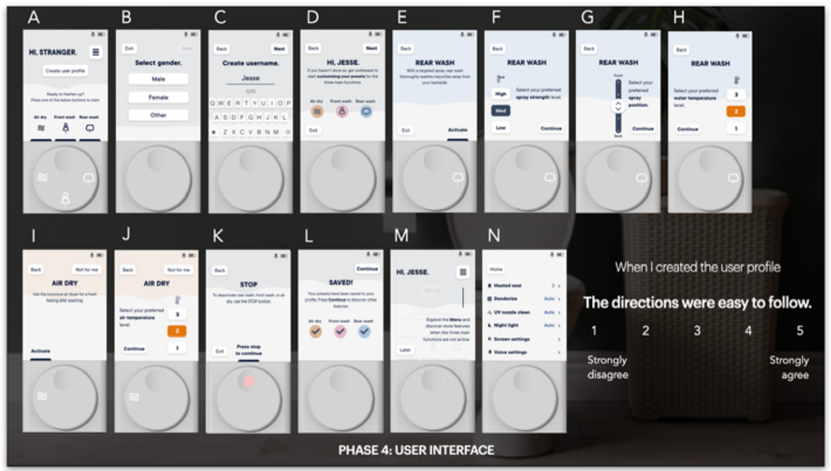

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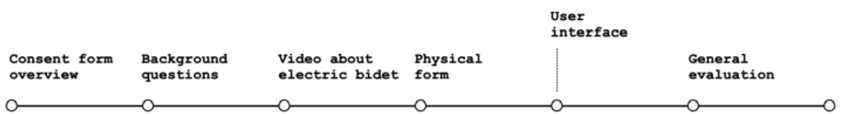

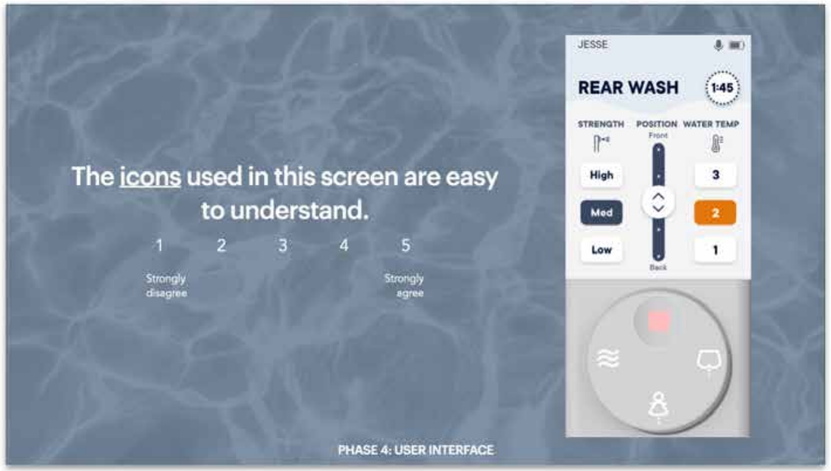

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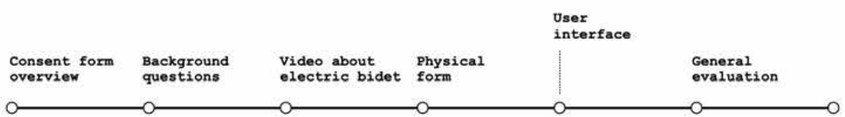
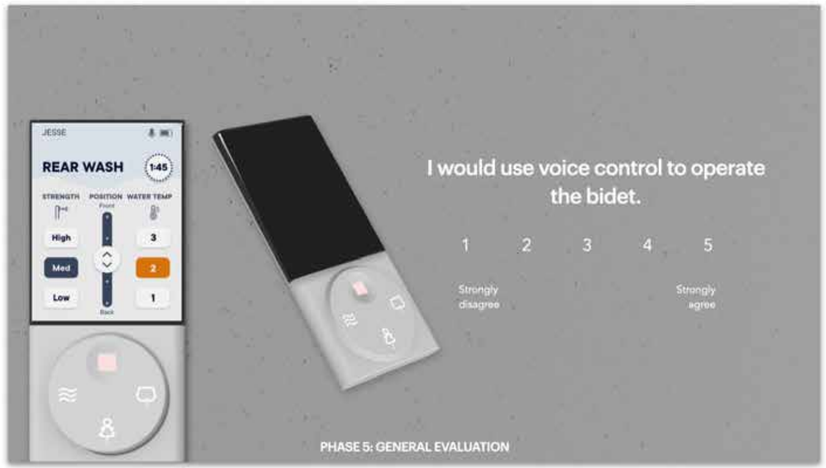
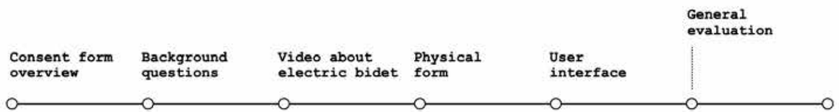






GENERAL EVALUATION

Q&A on their overall impression of the remote

EVALUATION TECHNIQUES

LIKERT SCALE

Q12: I think that **tapping** on the touch screen would be easy to do when the remote is **in my hand**.

1 2 3 4 **5**

Strongly disagree — Strongly agree

TRANSCRIPTION ANALYSIS

"When I say go and so for me ***I'm just going to want to hit the the button to start it.*** *So that it's. Turns on now if there's another button somewhere else where it says, you know when I sit down, it says welcome Jesse. And then it says start and I can push that button, boom. Then my presets go. But I'm I'm going to want to.* ***I'm going to want to basically have one button control.*** *Uh, and so either that's on the dial at the bottom or it's on the screen. But I don't want to have to go through. I…* ***I don't want to have to use the touch screen every time.*** *And I because it that would frustrate me. I wanted, you know, I just want it to be easy."*

EVALUATION

EVALUATION: PHYSICAL FORM
EVALUATION: USER INTERFACE & CONTROLS
EVALUATION: INFORMATION HIERARCHY
NEW DESIGN CRITERIA
FINAL DESIGN

PARTICIPANTS' BACKGROUND

On the younger side →

No feedback from anyone with mobility limitation →

Most participants were familiar with the concept of the bidet seat →

Number of participants: 10
Number of design professionals: 4

Gender: 6 male, 4 female
Age range: 60 - 70 years old

Limitation distribution:
6 with vision limitation (mild to severe)
3 with hearing limitation (mild to moderate)
1 with dexterity limitation (mild)
1 with cognition limitation (mild)
0 with mobility limitation
2 with no limitations

Bidet familiarity:
3 have used it
7 haven't used it
4/7 of those who haven't used it thought about buying one

EVALUATION
PHYSICAL FORM

SIZE

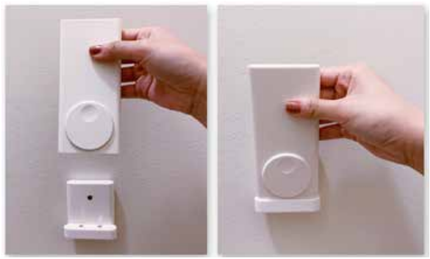
★★★★½ 4.7

The remote control is acceptable in size but **can benefit from being narrower** and more grip-able.

DETACHING FROM THE DOCK

★★★★½ 4.9

Detaching the remote is easy to do, a little less easy when it is docked **on the opposite side of the person's preferred hand**.

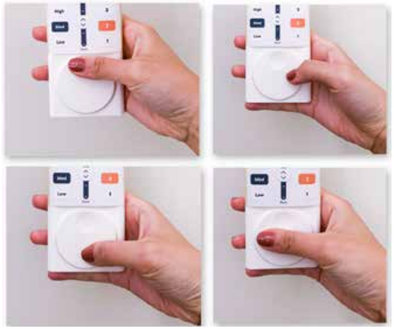


PHYSICAL FORM

CLICKING ON THE CIRCLE IN HAND

★★★★½ 4.9

Clicking on the circle in hand is considered easy to do but would be easier if the circle was placed **higher up**. 3 participants asked if it was for **scrolling like a wheel**, indicating that the functionality may seem confusing.



CLICKING ON THE CIRCLE ON A VERTICAL SURFACE

★★★★½ 4.8

Clicking on the circle when the control is on a wall is thought to be easy to do but less easy when the surface is on the **opposite side of the person's preferred hand**.

PHYSICAL FORM

CLICKING ON THE TOUCH SCREEN
IN HAND

★★★★½ 4.8

Clicking on the touch screen in hand is thought to be easy to do but participants may **prefer to use both hands** because of the width of it.

DRAGGING ON THE TOUCH SCREEN
IN HAND

★★★★½ 4.9

Dragging vertically on the touch screen in hand is thought to be easy to do unless the user has **tremor**.

PHYSICAL FORM

CLICKING ON THE TOUCH SCREEN
ON A VERTICAL SURFACE

★★★★★ 5.0

Clicking on the touch screen on a wall is thought to be easy to do if the surface is close to the toilet.

DRAGGING ON THE TOUCH SCREEN
ON A VERTICAL SURFACE

★★★★½ 4.7

Dragging on the touch screen on a vertical surface is thought to be easy to do but may require users to **lean their finger against the touch screen or other fingers against the surface**.

PHYSICAL FORM

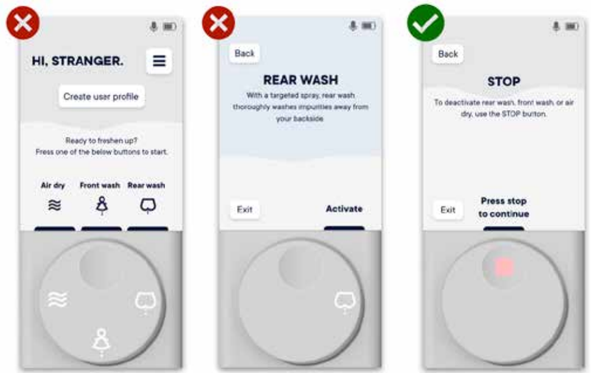
PRECISION & ACCURACY OF CONTROLLING THE REMOTE

★★★★☆ 4.9

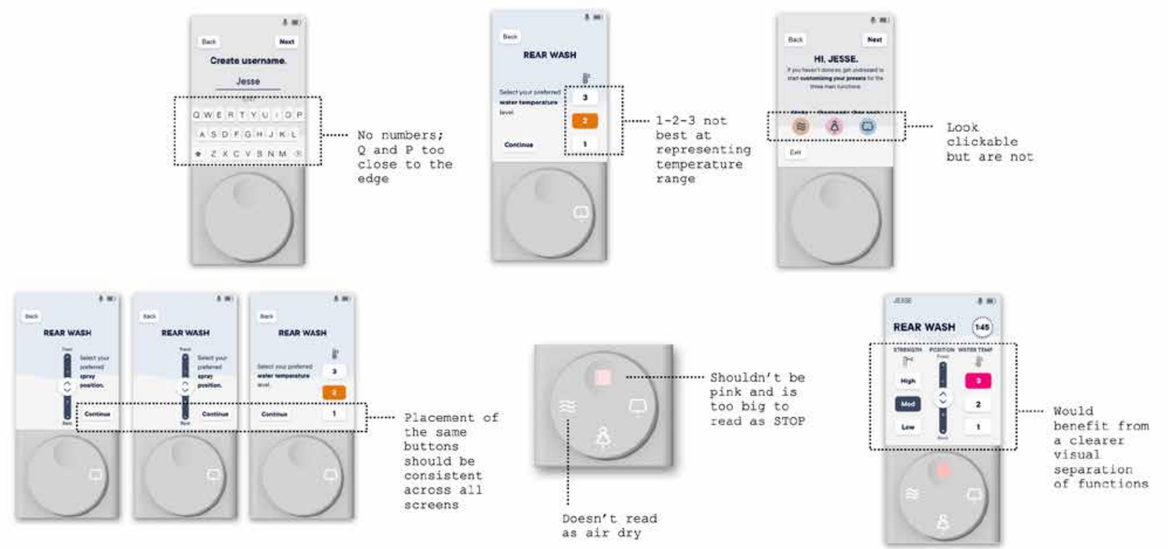
Participants thought that they would be able to control the remote precisely and accurately but **raised concerns over whether their older family members would be able to use the touch screen.**

USER INTERFACE & CONTROLS

Transitioning from touch screen and physical controls was **not** very clear to 10/10 participants. 10/10 participants would continue to interact with the touch screen naturally. However, 10/10 would have also "gotten used to" the way it worked. **Better directions** are needed.



USER INTERFACE & CONTROLS

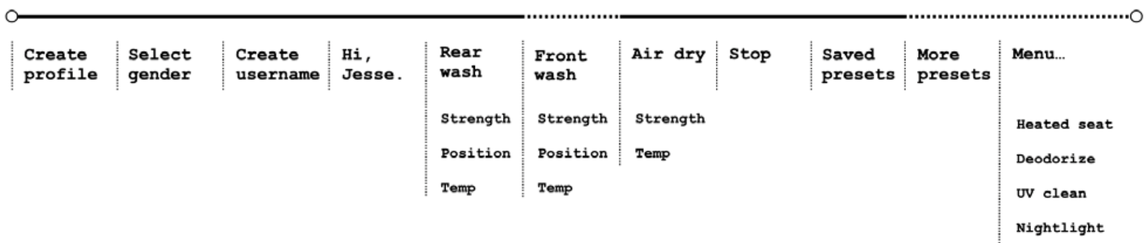


INFORMATION HIERARCHY

SEQUENCE "CREATE USER PROFILE"

★ ★ ★ ★ ★ 5.0

The logic of the sequence of screens made sense to all participants. They think that it is quick to get through and that there are **not many steps.**

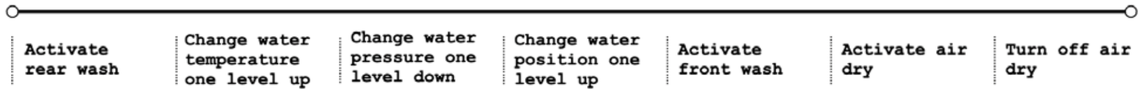


INFORMATION HIERARCHY

TASKS FOR “CONTROLLING BIDET”

★★★★½ 4.7

Overall thought that the tasks were easy to do. However, some participants expressed the desire to have **fewer buttons for the primary functions**. Specifically, one or two. They would prefer to have the screen dark as they thought that it looked **less busy without the graphics on the screen**.



INFORMATION HIERARCHY

COMBINATION OF TOUCH SCREEN AND BUTTONS

★★★★½ 4.7

Overall the combination of touch screen and buttons is appreciated.

Some participants think that when the screen is on, the remote is still **visually too busy**.

Some people are curious about **why it is not all touch screen** (their expectation). Upon revision, they agreed that differentiating primary from secondary functions was useful.

INFORMATION HIERARCHY

VOICE CONTROL

★★½☆☆ 2.8

The majority of participants are reluctant to use voice control. Reasons include:

Not wanting to be heard in the bathroom
Not finding voice control technology reliable
Preferring to use tactile controls

However, they would appreciate having voice control as an option for **emergency situations**.

INFORMATION HIERARCHY

TIME

★★★☆☆ 3.3

Participants do not think that timing their wash would be useful unless it contributed to how the bidet worked. Specifically, they would want to **set up a timer** for their wash or dry and wait until the bidet stops.They also want to learn about a **“recommended” time** to wash and set the time based on the recommendation.

DISCUSSION
ABOUT FEEDBACK

Information Hierarchy

The logic of the "Create user profile" sequence of screens made sense to all participants. They think that it is quick to get through and that there are **not many steps.**

Overall thought that the tasks were easy to do. However, some participants expressed the desire to have **fewer buttons for the primary functions**. Specifically, one or two. They would prefer to have the screen dark as they thought that it looked **less busy without the graphics on the screen**.

Overall the combination of touch screen and buttons is appreciated. Some people are curious about **why it is not all touch screen** (their expectation). Upon revision, they agreed that differentiating primary from secondary functions was useful.

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User Interface & Controls

Transitioning from touch screen and physical controls was **not** very clear to 10/10 participants. 10/10 participants would continue to interact with the touch screen naturally. However, 10/10 would have also "gotten used to" the way it worked. **Better directions** are needed.

1-2-3 not best at representing temperature range.

Placement of the same buttons should be consistent across all screens.

Air dry icon doesn't read as air dry.

Control panel would benefit from a clearer visual separation of functions.

Physical Form

The remote control is acceptable in size but **can benefit from being narrower** and more grip-able.

Detaching the remote is easy to do, a little less easy when it is docked **on the opposite side of the person's preferred hand**.

Clicking on the circle in hand is considered easy to do but would be easier if the circle was placed **higher up**. Some participants asked if it was for **scrolling like a wheel**, indicating that the functionality may seem confusing.

Clicking on the circle when the control is on a wall is thought to be easy to do but less easy when the surface is on the **opposite side of the person's preferred hand**.

Clicking on the touch screen in hand is thought to be easy to do but participants would **prefer to use both hands** because of the width of it.

Dragging vertically on the touch screen in hand is thought to be easy to do unless the user has **tremor**.

Clicking on the touch screen on a wall is thought to be easy to do if the surface is close to the toilet.

Dragging on the touch screen on a vertical surface is thought to be easy to do but may require users to **lean their finger against the touch screen or other fingers against the surface**.

Was the feedback relevant?
The virtual format of the user study was strong at presenting the information hierarchy, user interface, and controls. Therefore, I considered most of the feedback relevant.

Physical form could not be tested in person. Therefore, participants could not interact with a real physical object. Participants had to imagine the object in their hand and although they were presented with images and videos of the object in relationship to my hand, their guess accuracy is completely subjective.

Therefore, in terms of feedback on the physical form in relationship to hands, I considered the ones coming from **industrial design professionals**, who are more experienced at visualizing a 3D object from a 2D presentation, more relevant.

Comfortable size of the device is hardest to determine virtually. I used **1 percentile female hand grip circumference as the limit for the circumference of the device (30).**

NEW DESIGN CRITERIA

The newly added or modified design criteria are highlighted down below.

Information Hierarchy

1. The most **basic functions** need to be easiest to access at all times.
2. Information needs to be **grouped** in a way that is easy to understand.
3. **Deep menu-driven hierarchies** should be avoided.
4. **Include presets** to reduce the likelihood of changing settings with multiple users.
5. **Include heart rate sensor** for a hands-free user identification.
6. **Minimize the amount of information displayed at one time.**
7. **Include timer as a customizable feature** to reduce the frequency of interaction.

User Interface & Controls

1. **UI touch targets** should have at least 14mm in height and width. Larger is even better. Touch target spacing should be at least 8dp.
2. **The spacing** between physical buttons shouldn't be smaller than 1.5mm to avoid accidental activation.
3. **Icons** need to communicate functions clearly and should not create confusion.
4. **Labels** should be written in sentence case in sans serif and UI font size should be at least 12pt.
5. **Contrast** - if the text is smaller than 18pt, or if the text is bold and smaller than 14pt, the color contrast ratio should be at least 4.5:1. For all other text, the color contrast should be at least 3.0:1.
6. Include **multi-modal input and output** to accommodate for people with varying degrees of vision, hearing, and dexterity limitations.
7. The only gestures for controlling the UI should be **limited to tapping only.**
8. To avoid disrupting the circadian rhythm, include **"dark mode" or keep the screen turned off.**

Physical Form

1. Should be **operable by one hand** if held.
2. Should be **operable by one finger** if attached to a flat surface.
3. Needs to be **easy and comfortable to use. Grip circumference shouldn't be larger than 7.7 in.**
4. The right **orientation** should be apparent.
5. **Material** used should be lightweight and the finish should not be slippery. Needs to be waterproof and easy to clean.
6. Shouldn't be easily **misplaced.**
7. Easy integration into the **existing bathroom.**
8. **Primary functions** should be easy to access even when the remote is placed on the opposite side of a person's dominant hand.
9. Should be designed to **attach to common bathroom wall coverings and other vertical surfaces.**

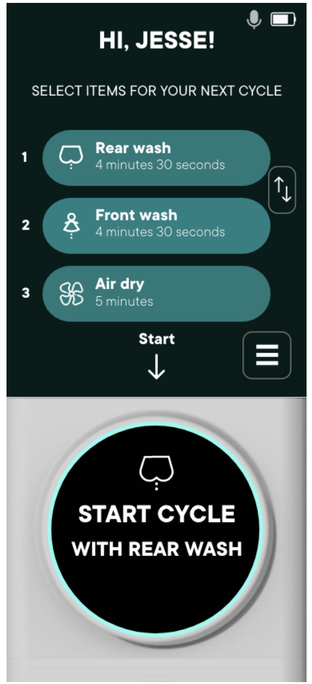
FINAL DESIGN

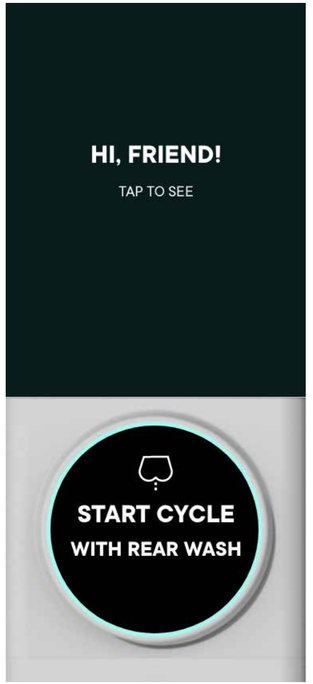
Grip circumference 7.65 in

Single large button

Dark color background

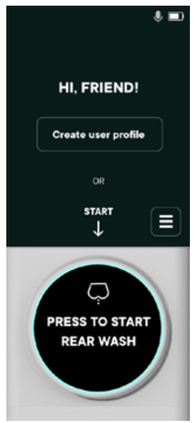
"Inactive" screen mode



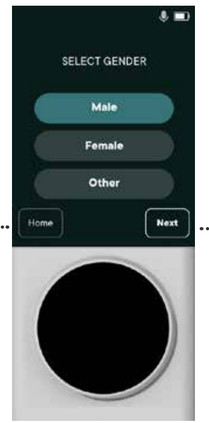


FINAL DESIGN
CREATE USER PROFILE

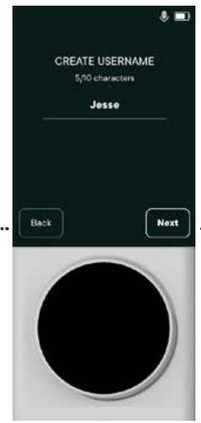
7 The only gestures for controlling the UI should be **limited to tapping only.**



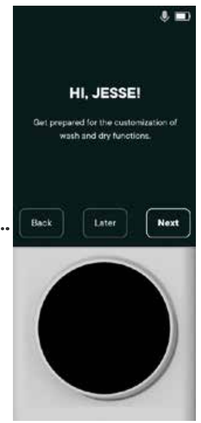
HOME PAGE
Click on create user profile



SELECT GENDER
Males will never have the option to adjust or even view front (feminine) wash.

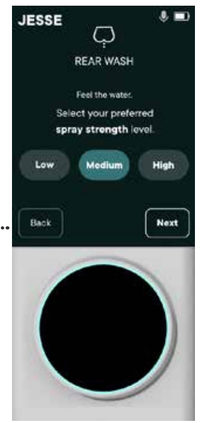


CREATE USERNAME

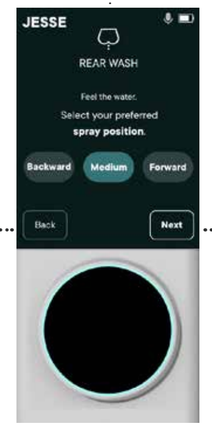


HI, [NAME]
Introduction to the three primary functions.

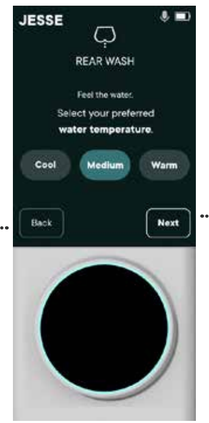
REAR WASH INTRO
Explanation of what rear wash does. Activating rear wash.



REAR WASH SPRAY STRENGTH SETTING
Adjusting spray strength based on preference.



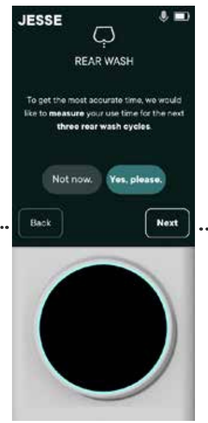
REAR WASH SPRAY POSITION SETTING
Adjusting spray position based on preference.



REAR WASH WATER TEMPERATURE SETTING
Adjusting water temperature based on preference.

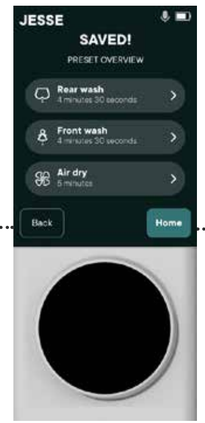
7 **Include timer as a customizable feature** to reduce the frequency of interaction.

REAR WASH - INITIAL TIME ESTIMATE
This is the **initial** recommended time for rear washing that is calculated based on user's preferred **spray strength**.



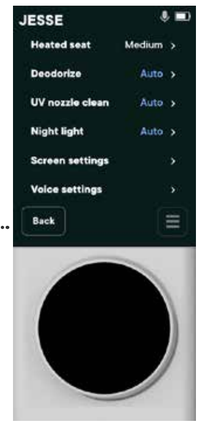
MEASURING TIME FOR THE NEXT REAR WASH CYCLES
Measuring multiple wash cycles will determine a more accurate wash time. Users will be asked to check whether they are clean in the next few rear wash cycles.

`FRONT WASH & AIR DRY (strength, position, temperature, initial time estimate, measuring the next few cycles)`



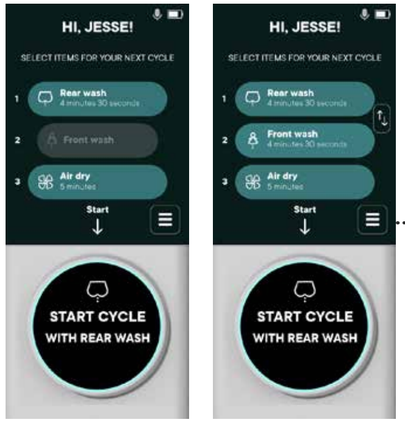
SAVED!
Settings are saved. Preview included.

HI, [NAME] EXPLORE MENU
Suggestion to explore more features. Optional step.

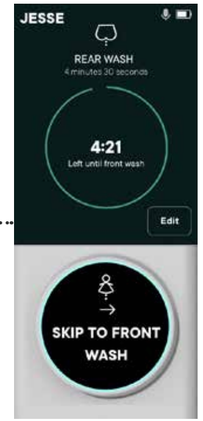


MENU
List of additional features (tertiary functions). Most are on Auto.

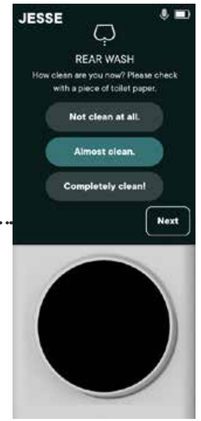
FINAL DESIGN
CONTROLLING BIDET

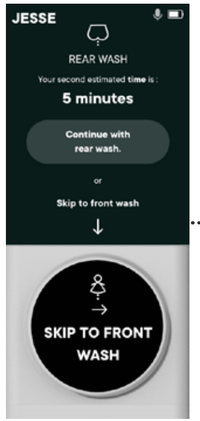


HOME PAGE - CYCLES
With a user profile, users can select which primary functions they want to use in the next cycle (there are only a maximum of 3). The default is always the **most preferred cycle** (either determined by the remote or selected by the user).

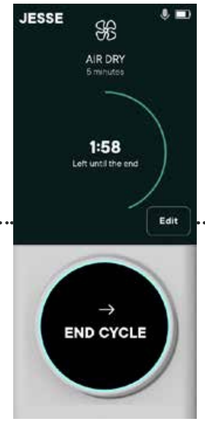


REAR WASH
Default screen will show a timer for rear wash in real time. Users have an option to change the parameters (secondary functions) of the wash when they click on **Edit** and switch back when they click on **Time left**. Secondary functions are buried deeper in the hierarchy compared to the previous version because it was found that they do not need to be accessed as frequently.

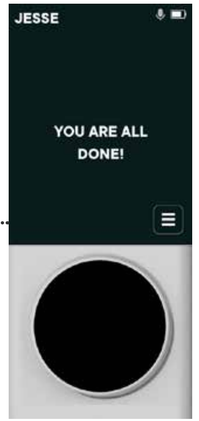




REAR WASH - TIME UPDATE
In the first few cycles of rear washing, the remote may ask users to report the effectiveness of the wash. This will help it understand how long it should spray to make the specific user clean. When the remote is done calculating the time, it will be able to switch automatically to the next task, thus further reducing the need for interaction.

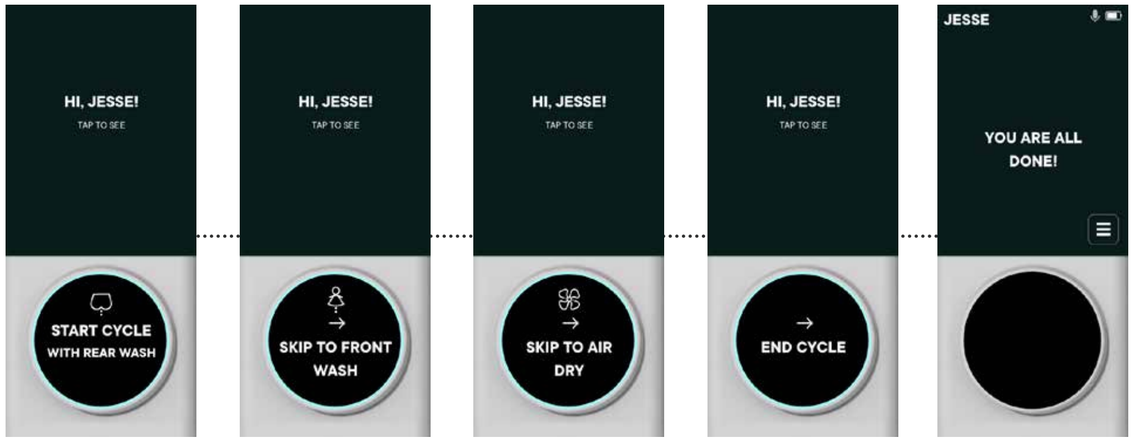


FRONT WASH / AIR DRY
Front wash and air dry work similarly to the previous example (rear wash).



YOU ARE ALL DONE!
Front wash and air dry work similarly to the previous example (rear wash).

FINAL DESIGN
CONTROLLING BIDET - NEAR FULL AUTOMATION



INACTIVE SCREEN MODE

When the remote learns the perfect settings for the specific user, the user can continue to use the remote without interacting with the touch screen. The touch screen can be turned off to remove "visual noise". This is the most ideal and desirable scenario for any user.

REFERENCE

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(7) Magnusson, C. et al. "Rapid Prototyping of Interface and Control Software for an Intelligent Toilet." Assistive Technology Research Series, vol. 27, 2011, pp. 101-111, doi:10.3233/978-1-60750-752-9-101.

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